

REMARKS

Review and reconsideration on the merits are requested.

STATUS

Claims pending at the time of rejection: claims 1, 2, and 4-14.

Claims canceled: claims 3, 15 and 16.

Claims currently amended: claims 1, 5, 6 and 9.

Claims newly added: claims 17-24.

Basis for the claim amendments is later discussed.

The Invention

In accordance with the present invention, a maraging steel is produced by vacuum melting and subsequent vacuum arc remelting (VAR). Applicants note that the combination of vacuum melting and subsequent vacuum arc remelting itself is known in the art.

The maraging steel produced in accordance with the present invention is most suitably applied to continuously variable transmission belts (CVT belts). The Examiner is requested to refer to, in this regard, claims 11-14.

In thin CVT belts, fatigue fracture property is determined by the size of non-metallic inclusions in the steel. See the present specification at page 3, lines 15-26. As a consequence, manufacturers of CVT belts have performed extensive experimentation to try to develop techniques of making non-metallic inclusions in a maraging steel to be used to form a CVT belt as small as possible, for example, even reducing the size to a size on the order of 0.1 μm .

One approach is the approach of JP '212. This involves using raw materials without TiN. This is based upon the recognition that when a Ti-containing steel width TiN inclusions is

subjected to VAR, the TiN inclusions aggregate to course and during melt processing. See paragraph [0006] of JP '212.

Applicants advise that the phenomenon of TiN coarsening during VAR processing is known. Given this knowledge in the art, the art has not been led to add an inclusion-forming element such as Mg to a TiN-containing steel before VAR processing. This is founded on the belief in the art that the addition of Mg would actually exacerbate the problem of coarsening of TiN during VAR processing.

Contrary to such prior art belief, in the accordance with the present invention Mg is positively added to the steel prior to VAR processing. The Mg forms oxide inclusions which can be the starting point of fatigue fracture of the steel, the Mg remaining in an electrode which is to be subjected to VAR processing.

Applicants submit that this fresh technical approach could not and would not have been conceived by one of ordinary skill in the art from the conventional teaching of JP '212. More specifically, in accordance with the present invention, *contrary to technical common sense, even though Mg is added in accordance with the present invention, the same being supposed to form non-metallic inclusions and the same being added to a Ti-containing steel, nonetheless non-metallic inclusions do not become coarse. Rather, coarsening of the non-metallic inclusions can be prevented. This is, Applicants submit, a quite unexpected technical advantage.*

According to experimentation which has been conducted regarding the present invention, when non-metallic inclusions are positively formed in melts during vacuum melt processing to obtain electrodes for VAR, and the electrodes are then subjected to VAR processing, it was confirmed that non-metallic inclusions were changed by decomposition of MgO during VAR

processing, namely changed to have a finer size which has no negative effect on the fatigue fracture properties of the resulting steel.

When Mg is positively added to an electrode for VAR processing, the form of the non-metallic inclusions in the electrode drastically changes in a product obtained by VAR processing. Claim 5 of the present application defines the form of such non-metallic inclusions in the maraging steel which has been obtained by VAR.

In the maraging steel of this invention, after VAR processing, the amount of Mg is limited to be less than 15 ppm, which does not adversely affect the toughness of the steel, and the amount of Mg is preferably less than 10 ppm, and even more preferably less than 5 ppm, further restraining the steel from containing an excessively high amount of Mg residue.

In summary on this point, Applicants respectfully submit that one of ordinary skill in the art would not have flown in the face of common knowledge regarding inclusion formation due to Mg by adding the inclusion-forming element Mg to a melt during melt processing, considering that Mg may become a primary factor of deteriorating the steel with respect to fatigue fracture properties. Certainly none of the prior art suggests refining non-metallic inclusions in a product steel after VAR processing.

There are essentially two types or methods of producing a maraging steel containing remaining Mg in the final product. The Examiner is requested to refer to the DECLARATION...1.132 submitted herewith.

A first type of method is that of the present invention in which a substantial amount of Mg remains in an electrode produced from a melt by vacuum melting after the electrode is subjected to VAR processing to reduce the amount of Mg.

A second type of method is that as is shown in JP '212. According to the second type of method, an electrode is produced from a melt by vacuum induction melting and the electrode contains an impurity level of Mg which comes from a lining of a furnace wall in which an electrode is produced from a melt by vacuum induction melting, whereafter the electrode is subjected to VAR processing to obtain an ingot containing an impurity of level of Mg.

In both types of methods, the product steels after the VAR processing contain residual Mg, which is about 1 to 2 ppm. However, the TiN inclusions of both types of products are much different from each other regarding size. Namely, *the size of TiN inclusions in the steel produced by the conventional method is greater by 1.5 μm or more than that of the steel produced by the method according to the present invention.*

The Prior Art

Applicants adopt the Examiner's nomenclature in the Action except for simply using the first patentees surname, referring to the prior art as JP '212, Floreen, JP '957, Uehara and Smith.

The Rejections

At the time of the Action, the following rejections, all under 35 U.S.C. §103(a), were posed.

Claims 1, 2, 5, 6 and 9 over JP '212 in view of Floreen and JP '957. Pages 3/4 of the Action.

The same claims over JP '212 in view of Smith. Page 6 of the Action.

Claims 4, 7, 8 and 10-14 over JP '212 in view of Floreen and JP '957 alone or further in view of Uehara. Page 8 of the Action.

The same claims over JP '212 in view of Smith alone or further in view of Uehara. Page 9 of the Action.

Claims 1 and 2 over Smith. Page 9 of the Action.

Claim 4 over Smith in view of Uehara. Page 9 of the Action.

Method Claims versus Maraging Steel Claims

Applicants wish to emphasize that the present application contains both method claims and maraging steel claims.

Should the Examiner be unconvinced of patentability of the method claims, the Examiner is requested to specifically focus on the maraging steel claims. Maraging steel claims have been allowed at the EPO. Certainly Applicants appreciate this is not binding upon the Examiner, but this does emphasize, Applicants believe, the need to consider fully on the merits both method and steel claims.

The Examiner's position is set forth in detail in the Action, and will not be repeated here except as necessary to an understanding of Applicants traversal which is now presented.

Traversal

Overview

JP '212

JP '212 is directed to the problem that TiN aggregates during VAR melting. See paragraph [0006] on page 2 and paragraph [0015] on page 3.

To solve this problem, JP '212 proposed to use raw materials which do not contain TiN inclusions. See paragraphs [0006] and [0010] on page 2.

Further, JP '212 proposes to conduct vacuum ESR melting before VAR melting, thereby trapping and removing TiN inclusions. See paragraph [0010] on page 2.

Thus, the solution posed in JP '212 to the problem with TiN aggregates during VAR melting is to reduce TiN inclusions in the raw material used, i.e., in the electrode, for VAR melting.

The concept of JP '212 is quite different from that of the growth of TiN inclusions being restrained during VAR processing.

Regarding JP '212 and the size of nonmetallic impurities in steel, in order to improve the fatigue strength of a steel, it is quite effective to make non-metallic impurities as fine as 1 μm or more. Reviewing the disclosure of JP '212, it should be appreciated how it is difficult to reduce the size of the non-metallic impurities by 2.7 μm (see Invention Specimen No. 5 and Comparative Specimen No. 1 and Table 3). JP '212 does not teach or suggest the advantages of the present invention which are achieved by the positive inclusion of Mg, and Applicants respectfully submit that such advantages are unexpected from the teaching of JP '212.

Claim 1 has been amended to clearly recite reducing the size of oxide inclusions and the size of titanium nitride inclusions.

Uehara

Uehara is directed to a maraging steel without Ti. Since no Ti is present, this eliminates any problem with TiN inclusions.

However, in the sense of the present invention, this is not a proper solution to the problem solved by the present invention because Ti is an important strengthening element in conventional maraging steels, as disclosed and discussed in Uehara at col. 2, lines 24-30.

Both JP '212 and Uehara make it quite clear that developing technology which would result in making the size of TiN inclusions small is an important problem to be solved today in the art.

The present invention provides technology which will enable the art to restrain the growth of intermetallic inclusions, including TiN inclusions, in a maraging steel containing Ti by carefully controlling the conditions during VAR melting.

JP '212 and Uehara do not suggest a solution of the present application in any fashion.

Floreen

Claim 1 of the present application recites that the maraging steel of the present invention contains from more than 0 to less than 15 ppm of Mg.

The amount of Mg added in Floreen can be up to 0.25%, i.e., up to 2,500 ppm.

In accordance with Floreen, Mg is added to the maraging steel for the purpose of deoxidation and/or providing the steel with malleability. See col. 3, lines 14-16 of Floreen. This is the only disclosure regarding the purpose of adding Mg in Floreen.

This is about 170 times the residual amount of Mg in the maraging steel of the present claims as recited in claim 1 and about 250 times the amount of residual Mg in the maraging steel of claim 17.

Applicants respectfully submit that Floreen in no fashion would lead one of ordinary skill in the art to select such extremely low amounts of Mg in a maraging steel, and this is certainly the case considering the fact that the effects of the present invention are quite different from those of Floreen.

JP '957

In JP '957, the maraging steel contains 0.001 to 0.1% Mg. In accordance with JP '957, Mg is added to the maraging steel for the purpose of deoxidation and obtaining good anti-stress corrosion cracking. In one embodiment, maraging steel of JP '957 contains 0.001% (10 ppm) of Mg. See Table 1 of JP '957.

JP '957 is, however, completely silent regarding an advantageous effects to using 10 ppm or less of Mg in a maraging steel.

Smith

Applicants view the disclosure of Smith as essentially the same as that of Floreen.

In light of the amendments to the claims, the rejection of the claims is traversed for the reasons now advanced.

As earlier discussed above, in order to improve the fatigue factor properties of the steel, it is necessary to pay attention to the size of intermetallic inclusions in the steel, as these inclusions can become the starting points of fracture. Smith and Floreen do not recognize the necessity of improving the fatigue fracture properties of a steel. In the case where Mg is used as a deoxidizer as is the case where Smith and Floreen (or, in fact, JP '957), an oxide of Mg, namely MgO, produced by deoxidation of the molten steel during vacuum melting should not remain in the molten steel but should be removed from the molten steel. In fact, in Smith and Floreen Mg is not added into a steel based on any specific disclosure, and there is only a general mention of strong deoxidizers such as Mg and Ca. It should be quite apparent that Smith, Floreen and, in fact, JP '957, are in no fashion aware of the advantageous effects of Mg as achieved in accordance with the present invention.

Traversal

Claim 1 is amended to recite that the consumable electrode contains oxide inclusions and titanium nitride inclusions.

Since JP '212 uses raw materials which do not contain TiN inclusions, this limit in the claims clearly distinguishes JP '212.

Further, to include TiN inclusions in the invention of JP '212, i.e., to so modify JP '212, would destroy the invention of JP '212.

With respect to Smith, the relevant disclosure in Smith which occurs at col. 2 is as follows (bolding added):

“The **subject steel** may also contain up to 0.25% each of boron and zirconium, up to 1% each of silicon and manganese, small amounts of up to 0.25% of calcium and/or sulfur, hydrogen, oxygen and phosphorus should be held to low levels consistent with good steel making practice. Cobalt is not required but **small amounts** can be present.

Smith provides no quantitative suggestion of how much a “small amount” of cobalt would be. In accordance with claim 6 and claim 21, the amount of Co is 5.0 to 20.0%. The Examiner has not established that this would be considered a “small amount” of steel in the sense of Smith or would be so viewed by one of ordinary skill in the art, especially since the invention of Smith can be characterized as follows:

“It has now been discovered that if the maraging steel composition of '254 ('254 is Floreen) is modified in respect of the titanium content and is aged in accordance herewith, a **cobalt-free steel can be produced in large section sizes...**” (bolding added); Smith at col. 1, lines 52-55.

Smith contains no teaching of the amount of Mg in any consumable electrode nor that the amount in the consumable electrode would be reduced in the final maraging steel.

Floreen, cited in Smith, is also directed to a cobalt-free steel. Floreen teaches:

“Accordingly, the problem from a metallurgical viewpoint was one of a developing a high strength, maraging steel characterized by acceptable toughness (as well as tensile ductility

and reduction of area) **without recourse to the constituent cobalt which contributed to toughness of the standard maraging alloys.**”(col. 1, lines 44-48, bolding added).

Floreen does teach at col. 2, line 9 et seq. that:

“Elements such as oxygen, hydrogen, sulfur, nitrogen and the like should be maintained at low levels consistent with good steel making practice.”

In claim 3, Floreen does claim a maraging steel which can contain “up to 0.25% each of calcium, magnesium, zirconium and boron.”

However, otherwise, Floreen contains essentially the same disclosure as Smith and is subject to the faults of Smith.

Although the Examiner only cites Uehara for the teaching regarding formation of a strip, Applicants wish to point out that Uehara is similar to JP ‘212 in teaching at col. 2, lines 12-23, that in order “to make TiN non-existent, it is effective to reduce Ti or N (nitrogen), however, extreme decrease of N is difficult...”.

Uehara proposes with respect to cobalt that the maraging steel have an “amount of Co contained therein is made to be in a very low level” (col. 2, lines 45-46), and in combination with not more than 0.1% Ti (col. 3, line 12), Uehara discloses that “the amount of each of Ti and Co can be compensated by adding a small amount of each of Si, Mn, Al and Etc” (col. 2, lines 48-50).

Thus, Uehara cannot suggest the process of the present invention since Uehara is basically similar to JP ‘212.

With respect to JP ‘757, in Applicants’ view, the disclosure of JP ‘757 adds nothing to the art discussed above.

Applicants respectfully submit that the prior art is properly combined only upon looking from the specification to the prior art, i.e., it is the teaching in the present specification which leads to the combination of prior art references.

None of the prior art significantly teaches in any fashion the aspect of controlling the amount of Mg in the consumable electrode and controlling the amount of Mg in the maraging steel so as to reduce the size and number of non-metallic and metallic inclusions.

While it is true that the isolated teachings which the Examiner relies on do in fact occur in the prior art, nonetheless it is quite clear that those teachings in no fashion are suggestive of the present invention where the amount of Mg is carefully controlled from the beginning to the end of processing so that during VAR the Mg may function to restrain non-metallic inclusions.

Basis for Claim Limits

The limit on the minimum amount of Ti and the ppm of oxygen and nitrogen at page 5, line 27 and page 6, line 2.

For the consumable electrode comprising oxide inclusions and titanium nitride inclusions, for example, page 1, line 25; page 2, lines 12 and 13; page 4, lines 2-7; page 6, line 22-28 and page 8, lines 6-7.

For controlling the growth of oxide and titanium nitride inclusions, this is based upon the used the words “set” in the specification at page 16, line 28 and page 17, lines 1,4,8,22. If the Examiner feels that language such a “set” should be used, the Examiner is requested to contact the undersigned so that this issue may be discussed. Applicants remain flexible in this regard.

For reducing the size of the oxide inclusions and the size of the titanium nitride inclusions, for example, see page 14, lines 1-5 and lines 16-22.

For the Mg content in the maraging steel being less than the Mg content in the consumable electrode, see page 10, lines 24/25, page 18, lines 13-28 and especially Table 1.

For the limitation regarding controlling the size of oxide and titanium nitride inclusions by the addition of a controlled amount of Mg to the consumable electrode to obtain a steel with improved fatigue strength, it is believed that “controlling” finds support at page 7, line 20; page 14, line 17/18; and page 18, lines 13/14. If the Examiner feels some other language is more appropriate, the Examiner is requested to contact the undersigned so that a telephone interview may be conducted. For this limit in general, see page 4, line 21; page 5, lines 1/2; page 5, lines 3-12; page 6, lines 22-27, page 6, lines 27-28 and page 14, lines 10-12.

For the concept that the consumable electrode contains oxide inclusions and titanium nitride inclusions, etc., see page 6, line 23 and page 7, line 5.

For the size limits added to the end of claim 1, see claim 5.

For new claim 17, see page 10 - page 11, line 1 and page 10, line 12 construed with page 10, line 19.

For claims 18 and 19, see page 10, lines 19-21.

For claim 20, the limit is taken from claim 6.

For claims 21 and 22, the more than 0 limit occurs in claim 1 and the 5 ppm value occurs Table 1, No. 7.

Claim 23 is patterned along the line of claims such as claims 11-14.

Claim 24 is patterned along the line of claims such as claims 11-14.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,

Peter D. Olexy / Bruce Kramer
Peter D. Olexy / Reg. No. 33,725
Registration No. 24,513

SUGHRUE MION, PLLC
Telephone: (202) 293-7060
Facsimile: (202) 293-7860

WASHINGTON OFFICE
23373
CUSTOMER NUMBER

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